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HENRY PICKERING BOWDITCH, PHYSIOLOGIST[1]

By Dr. WALTER B. CANNON

HARVARD MEDICAL SCHOOL

Sixty-eight years ago a young chemist, Charles W. Eliot, was the new president of Harvard University. Almost from the first he undertook the hard task of revolutionizing medical education. In his report for the academic year 1870–71, he wrote that the corporation and overseers had "changed the title of the Parkman Professor of Anatomy and Physiology in the Medical School. Physiology having been made a separate branch of instruction, and an assistant professor having been appointed to teach it, the Parkman Professor will hereafter teach anatomy only." The change, it was explained, was made with the assent of Oliver Wendell Holmes, for twenty-four years the incumbent of the combined chair. And later in the report President Eliot added, "The appointment of an Assistant Professor of Physiology and the equipment of a physiological laboratory has put that department of instruction upon a much better footing than before."

The comment is justifiable that no great change was required to bring about a considerable improvement. The literary Parkman professor had lavished his flowery adjectives on bodily structure, and had paid only incidental tribute to bodily function. He was, indeed, impressed by the revelations of the microscope, which, he declared, has "cleared up many uncertainties concerning the mechanism of special functions." Unfortunately, however, nature had been reluctant. "If any prying observer," he wrote, "ventured to spy through his magnifying tubes into the mysteries of her glands and canals and fluids, she covered up her work in blinding mists and bewildering halos, as the deities of old concealed their favored heroes in the moment of danger." But progress was recognized. "Science has at length sifted the turbid light of her lenses, and blanched their delusive rainbows."

Though there is evidence that Dr. Holmes in his lec-

[1] An address given at the celebration of the fiftieth anniversary of the founding of the American Physiological Society, Baltimore, April 1, 1938.

tures gave only cursory attention to physiological phenomena, he was probably more considerate than his predecessor, J. C. Warren, who let physiology take its chances with anatomy and surgery. Even Warren did not have the multiple tasks of Dunglison, at Virginia, who taught not only anatomy and physiology, but also materia medica, pharmacy and medical history. That bewildering array reached well beyond Holmes's range; nevertheless, Holmes, impressed by the diversity of his teaching duties, once declared that he occupied not a chair but a settee. It is probable that he was dissatisfied with this situation well before 1871, for in 1865 J. S. Lombard was appointed lecturer in physiology and held recitations twice a week in a summer course. He was succeeded in 1870 by William T. Lusk, father of Graham Lusk, who for a year gave the first physiological course at the Harvard Medical School that was accompanied by experimental demonstrations.

The conditions at Harvard were not unique. Instruction in physiology was usually a subsidiary activity, incidental to other teaching. The professor might be concerned primarily with any other aspect of medicine—with anatomy, pathological histology, diseases of children, psychiatry or gynecology, merely to mention a few actual instances of associated subjects. On the side, the professor lectured about bodily processes. There was one exception, in the career of J. C. Dalton, who, beginning in 1852, was the first American to devote full time to physiological teaching and research. He was, however, a lone worker, combining physiological and anatomical studies, an excellent expositor of his subjects, but not a leader of others towards new developments.

Into this realm of biology, almost uncultivated in the United States, Henry P. Bowditch entered in 1871. The year before, while stimulated by the fresh ideas and industry of Ludwig's laboratory at Leipzig, he had written: "The patient, methodical and faithful way in which the phenomena of life are investigated by the German physiologists not only inspires great confidence in their results but encourages one in the hope that the day is not far distant when physiology will take its proper place as the only true foundation of medical science." Imbued with this ardent faith he bought the apparatus to outfit a laboratory for physiological investigation (this personal gift was the "equipment" referred to by President Eliot), and installed it in two renovated rooms in the attic of the old medical building near the Massachusetts General Hospital. There he set to work as an assistant professor. No professor of physiology was over him, and when he was asked whom he was assisting, he replied, simply, "I'm assisting myself." That was the literal truth; at the time he had no helper.

Dr. Bowditch's description of physiological processes, well illustrated by exhibited proofs, was something new and strange. William James, who had received the Harvard degree in medicine four years previously, wrote to his brother, Henry, in November, 1872: "I go into the Medical School (*i.e.*, from Cambridge to Boston) nearly every morning to hear Bowditch lecture." It happened that a Mr. Weitbrecht, who taught me physics in the St. Paul High School, nearly a half century ago, had had a year of medicine at Harvard; he told me that his outstanding experience was hearing Dr. Bowditch's lectures in the 70's. They were stimulating, enthralling, he declared, full of the enthusiasm and vigor and interest of the young physiologist.

The two laboratory rooms in the attic soon became crowded with disciples. There they first experienced the thrill of discovery and were started on scholarly careers. Their interests embraced almost all phases of modern experimental medicine. Researches were undertaken in general biology, pharmacology, experimental surgery and pathology, physiological psychology as well as in the field of physiology proper. Among the men who worked with Bowditch in the early years of his professorship were Minot, the embryologist; J. C. Warren, the surgeon; Stanley Hall and William James, psychologists; Ott, the pharmacologist; Putnam, the neurologist; and J. W. Warren and W. P. Lombard (happily still with us), physiologists. As the man who suggested the research which led me to become devoted to physiological study I am glad to express my obligation to Bowditch.

During the first twelve years of his service to the Harvard Medical School Dr. Bowditch published almost twice as many scientific contributions as during the remaining twenty-three years. The lessened productivity in the last two thirds of his academic life was the consequence, I believe, of his acceptance of the deanship of the school, in 1883. He had excellent administrative ability. The tasks of administration, however, take away from an investigator one of the most important conditions for his success—his free *time*. An administrator's attention must be given to critical decisions, and gradually scientific interests become crowded aside—a consequence which is minimized by American university authorities. As dean, Dr. Bowditch established a number of valuable innovations; prominent among them was a highly creditable spoiling of the tradition expressed in the phrase that the faculty of the Harvard Medical School was a "Back Bay dining club." This he did by importing two outlanders—W. T. Councilman from Johns Hopkins, as professor of pathology, and W. H. Howell, from the same university, by way of Michigan, as associate professor of physiology. After he resigned from the deanship, however, Bowditch did not return to active work in the laboratory, but became more and more immersed in public and general university affairs.

Though Dr. Bowditch's scientific papers were not numerous, some of them have proved to have wide significance. His first published research, concerned with the properties of cardiac muscle, has become a classic in physiology because it reported, in the brief compass of twenty pages, two fundamental observations, the "staircase" phenomenon and the "all-or-none" law. The bearings of these phenomena on the processes in skeletal muscle fibers and the nerve trunk have been repeatedly recognized in the last twenty years. Bowditch himself was deeply interested in the functioning of the nervous system. He was one of the first to bring evidence of the indefatigability of the nerve trunk in its normal environment. And his study, with Warren, on the conditions which affect the knee jerk not only revealed temporal relations of excitatory and inhibitory impulses within the system, but also led the way to many other investigations, notably those of Lombard, in which the patellar reflex was the index of central states.

There is time merely to mention some additional researches by Bowditch alone or in collaboration with his students—the energy of ciliary motion, circumstances affecting the action of vasomotor nerves, the influence of anesthetics on vasomotor reflexes, illusions of motion, and the accuracy of judgment of positions in space. Besides these physiological and psychological studies, however, there was, at different periods, time-consuming attention to the phenomena of growth in children. Hall, himself a pioneer in the field, has referred to Bowditch as "the father of child study." As early as 1872 he had called attention to the greater increase of height of girls than of boys from about the twelfth to the fourteenth year. This phenomenon was subsequently confirmed by his own and other more extensive measurements and has since been recognized as a typical difference between the sexes. His report, issued in 1877, indicated six new lines of study in anthropometry; and in a review of his earlier data, published in 1891, he emphasized the importance of repeated measurement of the same children during the years of rapid growth, in order to allow accurate conclusions to be drawn regarding variability and relative size at various stages of adolescent development.

A characteristic of Dr. Bowditch, highly valuable to him as a physiologist, was his ingenuity. While in Ludwig's laboratory, in 1869, he devised the first apparatus (a simple use of the metronome) to mark time on the then newly invented kymograph; "It was real fun," he wrote to his mother, "to see how delighted the Professor (Ludwig) was with it." While in Leipzig he also designed the so-called "Bowditch clock," with arrangements for stimulating or for registering time at any desired brief intervals. Another neat idea was his scheme for weakening the strength of induced currents in the induction coil by turning the secondary instead of withdrawing it remotely along the axis of the primary. A new form of plethysmograph, a new apparatus for artificial respiration, a novel animal holder, a cannula for observing the vocal cords, a special arrangement of non-polarizable electrodes, and an extraordinarily comfortable lounging-chair, thoughtfully contrived, were other evidences of his inventiveness.

All physiologists should regard with gratitude Dr. Bowditch's labors in defense of freedom of research. The principles which he laid down in 1896 have been prominent in all the conflicts with the antivivisectionists since then. In brief they are (1) that the experimenters are no less humane than their critics and know much better than their critics the importance of the experimental method and whatever discomfort to animals it may involve; (2) that abuse of animals in research institutions has not been shown to exist; (3) that the governing bodies of such institutions have both the will and the power to stop abuses should they arise; and (4) that existing law furnishes sufficient protection against cruelty in the laboratory as well as against cruelty elsewhere. For many years, when the struggle to prevent the imposition of restrictive measures was centered in Massachusetts and was critical, Dr. Bowditch appeared at the legislative hearings, and because of his sterling character and high standing in the community his testimony convinced the legislators that the charges of the antivivisectionists were baseless and their efforts a danger to public welfare. His methods of defense of animal experimentation established precedents which have proved valuable in many subsequent conflicts.

Dr. Bowditch had numerous associations with physiologists in this country and abroad. He cooperated in the founding of both the International Physiological Congresses and the American Physiological Society. Of our society he was the second president. In 1877, when Michael Foster started the English *Journal of Physiology,* Bowditch was consulted and agreed to serve as one of the editors. In the late 90's, when the activities of the American physiologists appeared to warrant a means of publication here, he gave support and encouragement to W. T. Porter in establishing the *American Journal of Physiology.* Throughout his academic career he served on important commissions and committees, both professional and non-professional. The present buildings of the Harvard Medical School are a monument to the efforts of Dr. Bowditch and his life-long friend, John Collins Warren.

I first knew Dr. Bowditch when he was about 56 years old. His grayish hair and beard made him seem elderly; his erect carriage, however, and a peculiar springy walk gave the impression of strength and vigor. For twenty-five years he had been meeting

new medical students annually and giving them instruction. In my day his lectures had become routine, but they were admirably illustrated with well-prepared demonstrations. His manner with students was kindly though dignified, and his judgments were generous. For some years he had not been active in research. But when, in October, 1896, we started plans to use the recently discovered x-rays to study the process of swallowing, he paid close attention to them and gave the enterprise wholehearted support.

In the following years of association with him I became well acquainted with his rare qualities as a man. He was eminently single-minded. He seldom spoke of the past—the prospects ahead were more important. He was a natural leader, tempered by courtesy, fairness and good will. His friends were many and there was mutual devotion between him and them. His conversation was not witty, but he had a delightful sense of humor. I well recall his hearty laugh as he told of an overheard conversation between one of his little daughters and a neighbor's child. The visitor expressed surprise that Dr. Bowditch, a doctor, had no patients; the daughter explained, "Oh, my father isn't that kind of doctor; he is the kind of doctor who doesn't know anything!"

He had a life full of achievement. As a young man, in 1861, he left his studies to enter the Union Army. Though wounded while leading a charge he returned to the fighting forces and served to the end of the war. At the start of his professional career he brought back to the United States ideas and inspiration which he had received from Ludwig and the enthusiastic group in Leipzig. He established here the first physiological laboratory to which students were welcomed. In stimulating his students to carry on investigations he began a movement which has now spread almost everywhere in our land. He touched many aspects of research himself. He was intimately concerned with many new developments in modern physiology. He preserved extraordinary health and activity until he was well over sixty years of age; then a slowly progressive disease—paralysis agitans—crept upon him, and he had to endure the gradual loss of all his powers. As he waited for the end his friend from early manhood, William James, wrote to him. "I admit that the form of your tragedy beats that of most of us, but youth is a stuff that won't endure in any one, and to have had it, as you and I have had it, is a good deal gained." He had had it, to be sure, and had used it in admirable ways, leaving a lasting example of service to worthy causes as his legacy to American biologists.

SILAS WEIR MITCHELL, 1829–1914[1]

By Professor A. J. CARLSON
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DR. S. WEIR MITCHELL was born in Philadelphia on February 16, 1829. His parents were of Quaker stock. His father, Dr. John K. Mitchell, was a noted Philadelphia physician, a professor in the Jefferson Medical College, and ahead of his time in scientific and literary attainments.

Silas Weir was imaginative as a child, perhaps an early index of his prolific pen in the production of works of fiction in later years. Once he was put to bed on bread and water for 24 hours, for saying and sticking to it, that he had seen "pink elephants walking down Chestnut Street."

But his bent towards the more serious things of science also was early in evidence. He writes, in his fragmentary autobiography: "One of my greatest joys was to go with my father to his chemical laboratory in Locust Street, where he conducted experiments and gave lectures in a spring course."

In 1844 at the age of 15, Silas Weir entered the University of Pennsylvania, which he described as "a small affair with some good men." As a college freshman he was twice reprimanded for disorder, and once warned for deficiency in scholarship. He had not learned to work hard, his health was not the best, and he was much given to day dreaming. Young Weir's father urged his son to go into business, or at least cease dreaming and make up his mind as to his future work. Weir decided on medicine, to his father's disgust. His father said: "You have no appreciation of the life. You are wanting in nearly all the qualities that go to make success in medicine. You have brains enough, but no industry." It seems that even an able father may not know his own abler son.

Young Weir entered Jefferson Medical College. He writes thus concerning his first year as a freshman medic:

> I had to learn to work, to concentrate attention. It came hard. I used to go over and over some confounded bone, and fall asleep. The more abominable those dry bones became, the more I worked. After six months of this I began to hear Dunglinson's lectures on physiology. This was very interesting. Although neither he nor anyone else taught physiology with experiments or illustra-

[1] Address at the fiftieth anniversary meeting of the American Physiological Society, Baltimore, Md., April 1, 1938.

tions, *still it captured me.* I think I began, then, to develop the desire to leave no riddle unsolved, and this has made the laboratory a delight to me.

He graduated from Jefferson Medical College in 1850. The following year he spent in Paris for further medical training. Concerning this he writes:

I took courses designed for training in surgery. But I liked much better the lessons of Claude Bernard in physiology, and of Robin in microscopy. I recall one remark to me by Bernard. I said, "I think so and so must be the case." "Why think," Bernard said, "when you can experiment? Exhaust experiment, and then think."

It is probably not without significance in the outstanding adult achievements and character of Weir Mitchell that in his formative years as a medical student, he came under the influence of the two ablest teachers of physiology of that period both in America and in Europe. Dr. Mitchell's study in Europe was interrupted by illness (small pox), and cut short by his father's failing health. So in the autumn of 1851 he returned to Philadelphia, and started in the practice of medicine, a period of extraordinary achievements covering 63 years. His father urged him towards surgery, but young Weir found that he had neither the stomach nor the hand for surgery, so internal medicine became his bread and butter, physiology and experimental medicine his avocation. He writes:

"I was asked by several gentlemen to join in a summer school of medicine. I was to teach physiology, and this I was glad to do, as I always had some leaning in that direction, and had it not been for the fact that I failed later in my efforts to become a professor of that branch, physiology would have been my life long work. But I never was a good teacher, because of poor memory."

In the sixties Weir Mitchell became an applicant, in turn, for the professorships of physiology, both at Jefferson Medical College, and at the University of Pennsylvania Medical College. The appointive authorities in both institutions turned him down. I know not their reason, but I can not praise their perspicacity, for they rejected one of the ablest, if not the ablest man of their generation, a man that would have done honor to any faculty, in any school, in any country, at any age. Surgeon-General Dr. W. A. Hammond thus expressed his disgust and disapproval of Mitchell's rejection for the professorships in physiology: "It is an honor to be rejected by such a set of hairy apes." Oliver Wendell Holmes, commenting on Dr. Mitchell's rejection by the Jefferson School, said: "Perhaps it is hardly desirable that an active man of science obtain a professorial chair too early, for I have noticed that the wood in academic fauteuils has a narcotic quality which occasionally renders the occupants somnolent, lethargic, or even comatose." Louis Agassiz wrote to Dr. Mitchell, "I hope the selection of a professor of physiology in the most important medical school of the United States will be influenced chiefly by the opinion of the most competent men of the country, as I am satisfied that in that case your selection is assured, and being in position in which you can devote your abilities to further the advance of your science, there shall be another center of real progress in one of our institutions of learning."

Dr. Mitchell, who in national politics was a Republican, thought his rejection by the Jefferson Medical College and by the University of Pennsylvania was due to myopic democrats on the board and on the faculties of these institutions. Dr. Dalton, then professor of physiology in the College of Physicians and Surgeons in New York City, thought the reason was the then prevailing opposition of medical men to experiments in the medical sciences. Friends in Philadelphia told Dr. Mitchell that for every experiment he performed he would loose one patient. But these disappointments did not paralyze his hand, did not sour his soul. He worked, and sang, and ever urged his younger colleagues to fresh endeavors. In less than two decades Weir Mitchell had become the leading citizen of Philadelphia, and the leading man in clinical neurology in the United States, honored alike at home and abroad. But the reasonable procedure in appointment to university chairs, proposed by Agassiz eighty years ago has not yet been generally realized in this country. The "hairy ape" is still about, inside and outside our institutions of higher learning.

Weir Mitchell began his experimental and clinical publications in 1852, and during the following sixty years he published over two hundred and forty papers and monographs in these fields. His interest in the action of snake venoms started early and continued throughout his life, by personal work, by financial support, and by inducing younger investigators to lend a hand, such as Hammond, Keen, Reichert, Simon Flexner, Noguchi and Leo Loeb. Perhaps the outstanding contribution on this program was the discovery of the toxic albumins. In his work on the cerebellum (1869) he advanced, on the basis of experiments and clinical observations, the general theory that the cerebellum is an augmenting organ for the skeletal motor system, a theory later supported by the extensive work of Luciani.

The other main line of scientific pursuit of Weir Mitchell falls in the field of clinical neurology, evidently greatly conditioned by his army experience in our Civil War, 1860–64. He writes as follows concerning his service as an army surgeon:

My years in the United States hospitals were confined, except for a few days' work away from home, to the great hospitals surrounding Philadelphia, where in fact there were twenty-six thousand beds for the sick and

wounded. I declined the position of brigade surgeon. . . . My first appointment in October, 1862, was at the Filbert Street Hospital. . . . There I began to be interested in cases of nervous diseases and wounds of nerves, about which little was then known. In consequence, other men who did not like these cases began to arrange transfers to my ward.

This so interested the Surgeon General that he created a small hospital for nervous diseases in Christian Street. . . . The hospital soon outgrew the building, and again the Surgeon General created a new special hospital of four hundred beds. . . . There came out of this a series of well known papers and one book which revolutionized knowledge as to wounds of nerves. . . .

We worked on at notetaking often as late as twelve or one at night and when we got through, walked home, talking over our cases. Usually the work took four or five hours and we did it all in person. The late hours came two or three times a week and usually followed an inflow of cases of injuries to nerves after some serious battle. I have worked with many men since, but never with men who took more delight to repay opportunity with labor . . . the opportunity was indeed unique and we knew it. The cases were of amazing interest. Here at the time were eighty epileptics and every kind of nerve wound, palsies, choreas, stump disorders. I sometimes wonder how we stood it.

Mitchell did not stand it. His health gave away and he had to quit work for a rest period in 1864.

In 1872 he published the significant monograph on "Injuries to Nerves and Their Consequences." In another monograph entitled "Fat and Blood," he outlined his once famous, but now nearly forgotten "rest cure" for functional nervous disorders. There is probably more sound physiology and rational therapeutics in the "rest cure" than even realized by Dr. Mitchell. But other days, other gods and other thrusts into the fog. Freud is now the oracle in this field.

There are several versions as to the intellectual or circumstantial steps that lead to the Mitchell "rest cure." Dr. Keen opined that Weir Mitchell's "yeasty mind" began to orient the matter, stimulated by two patients with functional nervous ailments who happened to break their legs. There seemed to be mental improvements in consequence of the enforced rest while the bones were healing. But Weir Mitchell is reported to have told Dr. Osler that the idea came to him purely as a trial and error, having a psychotic patient whom another physician had failed to help by exercise, he decided to put the patient to bed. But Weir Mitchell was a striking, kind, forceful person. The temporary or lasting effects of some therapeutic procedure in functional nervous disorders seem to depend, in part, on the personality of the doctor who prescribes the procedure.

Dr. Mitchell offered through the American Physiological Society out of his own pocket two prizes towards defraying the expenses of experimental research on the nervous system. The second of these Mitchell prizes was awarded in 1891 to W. H. Howell and G. C. Huber for their work on the degeneration and regeneration of peripheral nerves.

Eight years after his graduation from the Medical School, Dr. Mitchell published a digest of the "American Papers on Physiology" in the two previous decades. He called it aptly a "melancholy catalogue," when compared to the contributions to physiology in Europe during the same period.

Weir Mitchell was a man, like Beaumont, and (in his earlier years) Meltzer, whose character, intelligence and restless curiosity forced them to break new ground in the medical sciences, though institutional connections or aids were lacking. In a letter to Owen Wister (1908) Mitchell said: "I have been through a time in my life when I was working at scientific problems, earning my living, harassed by anxieties, had but slender means, and was yet aware that for great scientific research a man must have leisure—freedom from care."

I met Dr. Weir Mitchell but once, in the year 1904, in Philadelphia. He made a lasting impression on me, with his great dignity, his patrician bearing, his kind and thoughtful visage, something like the impressions made on me years later by Pavlov of Leningrad, and Schaefer of Edinburgh. Weir Mitchell knuckled down to no man, be it the King of England or the President of these United States. He was surely both kind and stimulating to his younger colleagues. Writes Dr. W. W. Keen:

I was sitting in Dr. Brinton's office, with a skull in one hand and in the other a volume of Gray's Anatomy, the blinds opened and I looked out between them into a pair of brilliant eyes. A tall, fair, energetic man was standing on the sidewalk. Then and there he asked me, a doctor three days old, to help him in his snake-poison experiments. Thus, began the most powerful influence of my professional life.

He was a prodigious worker, with a very large medical practice. He wrote some fifteen stories or novels and some verse, "as a recreation." A good friend said of him: "Dr. Mitchell has no more sense of humor than a poker." That characterization hardly squares with his life and letters, and the opinion of others among his many distinguished and devoted friends. It is told that, confronting an hysterical lady patient, and argument and persuasion having failed to induce her to get out of bed, Dr. Mitchell said: "If you do not get out of that bed in five minutes, I am going to get into that bed with you." The five minutes being up, Dr. Mitchell with great deliberation took off his coat, and then his vest, but when he started to take off his pants the lady got out of the

bed in a hurry and in a fury. One may question the efficacy of this therapeusis in our country in 1938, at least outside the city of Philadelphia. There is, humor, banter, as well as elegy in this letter to his niece, Hester Hone.

> We are just in from fishing and are sitting in our shirt sleeves, looking very lazy and as brown as King Alfred's cakes. I got one salmon but he was as troublesome as a young lady, and did require a good deal of attention before he said yes. And after all he weighed only 21 pounds. Oh, if I could have you in a canoe for an afternoon, and let you take a 30 pound salmon, and show you how beautiful the woods are, and the river when the sun is low, all a rolling surface with blue, and green and gold, with bits of brown and hanging purples.

Weir Mitchell saw an unusually full life in his labors, in his friendships and in later approbation of society. He also had his share of shadows. To be sure, his earlier frail frame changed into a magnificently robust and vigorous manhood. But despite his great industry and his great success, he could write in 1874: "I am meditating much work to fill the chinks of loneliness." When a doctor friend tried to cheer him after the death of his beloved twenty-two year old daughter, he replied: "Can you mend an old man's broken heart?" The following lines ("Ode to a Lycian Tomb") written by Weir Mitchell and published in 1899 seem to say that the pean of pessimism of the ages: "Vanitas vanitatis, omnis vanitas est," will now and then touch the spirit of any person whose life lingers and who achieves a significant understanding of man:

> Thou who has wept for many weep for me,
> For surely I, who deepest grief have known
> Share thy stilled sadness, which must ever be
> Too changeless and mending, like my own
> Since thine is woe that knows no time's release
> And sorrow that can never compass Peace.

As a final attempt to make a great colleague of the past walk and talk at this semicentenary permit me to quote the following paragraphs from Dr. W. H. Howell's History of the American Physiological Society—the first 25 years:

> Weir Mitchell was the outstanding physiologist in the United States during the two decades preceding the establishment of the physiological laboratories at the Harvard and the Johns Hopkins Universities. . . . He was probably the most distinguished and the most widely known member of the American Physiological Society at the time of its foundation. . . . The Society was fortunate, indeed, in having among its original members five men, Mitchell, Wood, Welch, Osler, and Vaughan who were or who soon became the acknowledged leaders of scientific medicine in this country.

With these glimpses of the past, and standing in the turbulent present, what about to-morrow? Is the output of significant contributions by American physiologists still going sharply up? Is it reaching a plateau? Is there a descent in quality? What are our desiderata and the ways to their approach?

(1) Confronting the physiologists of to-day and to-morrow is a complexity of unsolved scientific problems, more varied and seemingly more fundamental than could have been conceived even in the dreams of Mitchell, Bowditch and Martin, or tackled by the techniques of their generation. So we need not weep for worlds to conquer, or excuse sloth by lack of problems to solve.

(2) To-day, the physiological approach, that is the dynamic and experimental as over against the static, the structural, the primarily descriptive, has conquered practically all biology and medicine in this and other countries. Excellent physiological research is coming from laboratories of Zoology and Anatomy, from Medicine and Surgery, from Psychology and Bacteriology. The battle line of physiological attack on the unknown has then been greatly extended in the last fifty years by the biologists themselves, as well as by the pathfinders in the physical sciences. I look upon this as a great stimulus to the present generation of physiologists, to try to hold their own, to endeavor, if possible, to lead.

(3) Physiology is to-day even more important in the medical school, in the training of physicians, than it was fifty years ago, and I can see no indications of its diminishing importance is this field. Moreover, physiology has gained and is gaining status as university discipline, along with chemistry and physics, in our stronger universities and colleges. Fifty years ago physiology in the United States was scarcely more than a feeble handmaiden to medicine.

(4) The teaching of experimental physiology is in the process of significant extension to the levels of general college education, and even into the high school. Society is slowly but surely realizing that the rule of reason as regards health, happiness, and the farewell to fear, require a more thorough understanding of the machinery of our bodies than that contributed by the number of bones in our skeleton, and the action of whiskey on the gastric mucosa. The teaching of individual health, of public health—a desideratum for every citizen, old and young, white, yellow or black—becomes an exercise for parrots, for morons, unless based on our dynamic body machinery (that is, physiology) in health and in disease. Our more perspicacious colleagues in botany and zoology saw long ago that even such lovely human processes as colonic peristalsis may involve as much fundamental biology as ameboid movements, reproduction in the sporophytes or the sociology of the honey bee. In other words, teaching of physiology in the service of society

is going beyond and below the field of medicine as conceived and practiced 50 years ago. It has become co-extensive with the field of preventive medicine, which we talk about to-day, and dream about for to-morrow.

(5) A new problem now confronts the workers in physiology, or at least a different aspect of the problem than that facing our colleague of 50 years ago; that is; the publication of research. The steadily increasing number, as well as the number of annual volumes, of scientific journals is becoming an economic problem, if not a housing problem, both for the investigators and the libraries. The heat from the friction between editors and contributors is oxidizing some of our verbosity and redundancy. But when editors force elimination of experimental protocols and other essential data to the point, where independent evaluation of conclusions becomes difficult if not impossible, we have reached a crisis, and that crisis is here. What to do? The final answer is not more volumes or more journals. Nor is it less research, or publications of mere conclusions. Let us see to it that an answer is not essayed via the ancient torch of the modern Saracens. National depositories for experimental data, perhaps in the form of Leica films, available to investigators under government frank, might be the permanent solution, but this seems far away. And in the meantime we spawn more journals, waste much epinephrine, and there is no peace.

(6) Some of my colleagues, particularly those of advancing years, see clouds ahead on the score of the number and the caliber of men and women we train annually in our laboratories for service in physiology: Some think we train too many, or at least too many of inferior caliber. Some even propose a control of recruits on the principle of the labor unions and the guilds of the middle ages. I think this would be as wasteful and unfortunate as it is undemocratic. I am not so pessimistic, as our late colleague Meltzer, who said to me a few years ago that we were breeding cretins as the next generation of physiologists. In the first place, none of us can either pick out or train genius. Jefferson Medical College evidently did not think very much of Weir Mitchell when he graduated, or for a couple of decades afterwards, for that matter. But Weir Mitchell carried on. Provided the doors to opportunity are opened by the keys of proved achievements only, we should not worry so much about numbers. Of course, you perceive I am reasoning on the ancient, and formerly biologically sound and acceptable theory that we must create our own opportunities, that we must scratch for our own living. One thing seems fairly clear: The steep curve of establishment of new physiological laboratories in our educational institutions is rapidly reaching a plateau in the United States. But I foresee a marked increase in physiological laboratories and physiological research in industry and in governments. In view of the great extension of the physiologic battle line of to-day and its probable further extension to-morrow, we should probably see to it that our graduate students become as well grounded in chemistry, physics, pathology and medicine as they are, or should be, in the dynamics of the amoeba, the frog, the guinea pig, and the dog.

(7) So you will note I am fairly optimistic about science, and our branch of science, for to-morrow. And I hope that this qualified optimism is not the euphoria of senility. I have serious apprehension on one point only, namely, the danger to science and to the freedom of man in the cyclical psychosis of society. We hear voices saying: "Science is bankrupt," "Science is at the root of our present universal chaos and misery." "We must declare a moratorium on science." "Let us seek escape from the reality of the present in pre-scientific faiths," etc. As I read history, all great achievements in science have come through individual endeavors by relatively free men. In the land of the dictator the man of science becomes either a slave or a court jester. A regimented, a dictated science is science in eclipse. Weir Mitchell lived through the period of our Civil War. That local mental aberration was serious enough. And all its sequelae are not yet healed, after an elapse of more than 70 years. But now the psychosis of salvation through violence is pandemic. The dictator screams: "We think with our blood," and men cheer. New faiths, new formulae, new fetishes, new saviors via the sword, spring up over night from troubled soils, all with the same old clay in their feet, the same old sawdust in their skulls. Science and violence are incompatibles. But may we not gather some courage from the fact that chaos and violence do not seem to be permanent states, even in gaseous matter? Those of us who individually escape the pan-psychosis have to answer the question: Is the life of the termite and the bee worth the while for man? There is some courage in numbers, and to-day we—men of science—are a large company. Were we united it should be easier for us to say *no* to violence, than for Galileo, who stood alone. When pressed nigh onto despair, the offer of "collective security" in exchange for relative personal freedom is tempting, indeed. But look about you, and at the past. Is it not true that when men have bartered personal freedom for collective security they have lost freedom without gaining a security worth having? Is it not a fact, that cave fishes have some security—but no vision, while the eagle has scant security but enjoys both vision and wings?

SCIENTIFIC EVENTS

VIENNA AND THE INTERNATIONAL CONGRESS OF PSYCHOLOGY

At the thirteenth annual business meeting of the Midwestern Psychological Association held at Madison, Wisconsin, on April 22, 1938, the following set of resolutions was adopted:

Whereas, The Twelfth International Congress of Psychology, to be held in 1941, has been awarded to Vienna because of the honored place Austrian psychologists have occupied and now occupy in the history of psychology, and

Whereas, This decision was reached on July 31, 1937, when Austria was an independent nation, and

Whereas, Austria was forcibly annexed to Germany on March 11, 1938, and was consequently declared to be a province of Germany, and

Whereas, Germany is now governed by a Nazi dictatorship, which has subordinated the integrity of science and of scientists to a political creed, which has caused the dismissal of many scientists and scholars from their positions, which has caused the emigration of many of the nation's outstanding scientists and scholars to other countries, and which has so injured German psychology that it no longer holds the eminent position it once did, and

Whereas, The same forces have already confiscated the passport and available funds of Sigmund Freud, have caused the dismissal, arrest, or suicide of many other Viennese scientists, and are thus in the process of reducing Vienna and the rest of Austria to the same anti-intellectual, anti-scientific status that is now Germany's official position, and

Whereas, The attendance of the world's psychologists at an International Congress in Vienna could be interpreted at best as a lack of opposition to, and at worst as an endorsement of Nazi treatment of science and of scientists, therefore, be it

Resolved: 1. That the Midwestern Psychological Association goes on record as opposing the holding of the Twelfth International Congress of Psychology in the city of Vienna;

2. That it requests the executive committee of the International Committee to select a meeting place for the Twelfth International Congress in a country which permits the unhampered development of psychology and of other sciences;

3. That it requests the executive committee of the International Committee to add to its membership the name of Professor Karl Bühler as an associate, because Professor Bühler was elected president of the Vienna Congress, and because this same thing was done for Professor Emilio Mira, of Barcelona, when the Eleventh Congress was changed from Madrid to Paris.

J. P. Guilford,
Secretary-Treasurer

ORGANIZATION OF AN INDUSTRIAL RESEARCH INSTITUTE

Dr. Maurice Holland, New York City, director of the Division of Engineering and Industrial Research of the National Research Council, is acting as executive officer of a newly established Industrial Research Institute, an organization of research executives, affiliated principally with middle-sized and small industrial corporations, which was formed following a series of preliminary meetings held at the Engineers' Club, New York.

The institute was established following a survey as to the need for it after men, known for research activities in their respective fields of industry, had expressed a desire for such an organization in which they could discuss laboratory organization and administration and other problems common to directors of scientific research.

Robert B. Colgate, vice-president of the Colgate-Palmolive-Peet Co., Jersey City, N. J., has been named chairman of the executive committee of the institute, and H. W. Graham, general metallurgist, Jones and Laughlin Steel Corp., Pittsburgh, Pa., is vice-chairman. Other members of the executive committee are: O. A. Pickett, research director, Hercules Powder Co., Wilmington, Del.; Donald Bradner, director of research and development, Champion Paper and Fiber Co., Hamilton, Ohio; H. Earl Hoover, vice-president, The Hoover Co., Chicago; J. M. Wells, vice-president, American Optical Co., Southbridge, Mass.; G. E. Hopkins, technical director, Bigelow Sanford Carpet Co., Thompsonville, Conn., and Oliver Kamm, scientific director, Parke, Davis and Company, Detroit, Mich.

The executive committee will serve as a committee of the National Research Council during its formative and developmental stages. The Division of Engineering and Industrial Research of the council has made its facilities and technical resources available during the organization period. The present headquarters are at the offices of the division at 29 West 39th Street, New York. The institute will not duplicate the services of any existing organization and wherever it appears that any task can be better done by other organizations, it will be turned over to them.

Representatives of forty industrial corporations attended the first preliminary meeting in March when results of a survey of five hundred research laboratories to determine the extent of their needs were reported. The survey covered many fields of industry and major industrial areas of the country. It included problems of research laboratory organization and administration, the selection and handling of personnel, control and construction of budgets, relation of laboratories to other departments, coordination of research with market studies, sales promotion, etc. Improvement of the general efficiency of laboratory operation and increasing the return on the research investment were matters of specific interest.

THE FIELD MUSEUM OF NATURAL HISTORY

THE annual report of the Field Museum, Chicago, was published on May 20. It is Director Clifford C. Gregg's first report, he having been elected last May director to succeed the late Stephen C. Simms. In the introduction to the report Mr. Gregg calls attention to the pressing needs of the institution. He writes:

The uncertainty of financial support continues to be the chief problem of Field Museum. There is great need for a larger scientific staff, more nearly proportioned to the scope of the institution. Additional staff members could give the public far greater use of the splendid collections now in the museum, through expansion and improvement of exhibits, further extension of educational activities, development of research facilities, increased production of publications and various other means.

There is great need of a pension fund adequate to meet the requirements of a staff most of whom have spent many years in the service of the institution. A splendid beginning on such a fund was made through the original contributions of President Stanley Field many years ago. Various other urgent needs of the institution since that time have taken all available funds, so that the pension fund is now woefully inadequate. The need of increased endowments becomes more marked year after year. Were it not for the generous support of Mr. Marshall Field, Mr. Stanley Field, Mrs. James Nelson Raymond, Mrs. Diego Suarez, and a few others, the activities of the museum would necessarily be curtailed at once. Rigid economies are required in any case under present-day conditions.

The year 1937 was a successful one from the standpoint of service rendered by the museum, as there was an increase in attendance, and notable accomplishments were made in various activities for the public and for the advancement of science. For the first time since 1933 the museum showed a substantial increase in attendance. The total figure of 1,290,023 visitors was a gain of a little more than 100,000 over the year before. On August 4 the museum received its twenty millionth visitor since the present building was first opened on May 2, 1931. Average attendance in this building has been one and a quarter million persons per year, contrasted with 228,000 annually in the former location.

Attendance at the museum itself does not indicate fully the scope of the institution's service. The department of the N. W. Harris Public School Extension benefited some 500,000 children by the circulation of nearly a thousand traveling exhibits among more than 400 Chicago schools. Nearly a quarter of a million children were reached with museum instruction supplementing their regular studies by the James Nelson and Anna Louise Raymond Foundation for Public School and Children's Lectures. Contributions to adult education were made by the free courses of illustrated lectures on science and travel, the 110,000 volumes in the museum library, and the reference collections of study material in each of the scientific departments of the museum—anthropology, botany, geology and zoology.

Several new appointments to the museum staff are reported. These include: Richard A. Martin, curator of Near Eastern archeology; Dr. Julian A. Steyermark, assistant curator of the herbarium; John R. Millar, curator of the N. W. Harris Public School Extension, and five volunteer associates (working without compensation) as follows: Clarence B. Mitchell, research associate in photography; Paul G. Dallwig, layman lecturer; Mrs. Hermon Dunlap Smith, associate in ornithology; Mrs. Edna Horn Mandel, associate, Chinese collections, and Miss Elizabeth McM. Hambleton, associate, southwestern archeology.

AWARDS IN THE WILLIAM LOWELL PUTNAM MATHEMATICAL COMPETITION

ACCORDING to an announcement from the office of the secretary-treasurer of the Mathematical Association of America, the department of mathematics of the University of Toronto has won first prize, five hundred dollars, in the first annual William Lowell Putnam Mathematical Competition. The members of the winning team were A. J. Coleman, I. Kaplansky and N. S. Mendelsohn. The second prize, three hundred dollars, is awarded to the department of mathematics of the University of California at Berkeley, members of the team being S. P. Frankel, W. M. Kincaid and C. W. Lippman. The third prize, two hundred dollars, is awarded to the department of mathematics at Columbia University, the members of the team being S. W. Benson, B. A. Jacobson and Joseph Statsinger. In addition to these prizes to departments of mathematics with winning teams, a prize of $50 each is awarded to the following five persons whose scores ranked highest in the six-hour examination (names arranged alphabetically): Robert Gibson, Kansas State College, Fort Hays; I. Kaplansky, University of Toronto; G. W. Mackey, Rice Institute; M. J. Norris, College of St. Thomas; Bernard Sherman, Brooklyn College. One of these five will receive a $1,000 year scholarship to Harvard University, this award to be announced later. The members of the three winning teams will receive individual prizes of $50, $30 and $20, according to the ranks of their teams, and all individuals receiving prizes will also receive medals.

The William Lowell Putnam Mathematical Competition examination was held on April 16, and 163 mathematics students from 67 colleges and universities in the United States and Canada took part. A qualified reader graded the examination books, complete anonymity being maintained throughout by the use of numbers instead of names for identification.

This competition was designed to stimulate a healthful rivalry in the undergraduate work of mathematics departments in colleges and universities in the United States and Canada and is open only to undergraduates. The examination questions were taken from the fields of calculus, higher algebra, differential equations and geometry.

The competition is made possible by the trustees of the William Lowell Putnam Intercollegiate Memorial Fund, left by Mrs. Putnam in memory of her husband, a member of the Harvard class of 1882. It is sponsored by the Mathematical Association of America and is held annually.

W. D. CAIRNS,
Secretary-Treasurer

DEGREES CONFERRED BY THE UNIVERSITY OF PENNSYLVANIA ON THE OCCASION OF THE DEDICATION OF THE FRANKLIN INSTITUTE

As part of the ceremonies of the dedication of the Franklin Institute of Philadelphia, degrees were conferred on May 20 by the University of Pennsylvania on five scientific men who gave lectures. In conferring these degrees Dr. Thomas S. Gates, president of the university, made the following citations:

GEORGE DAVID BIRKHOFF: For many years mathematicians have recognized you as a leader; your work and inspiration have guided the path of many to high places in American research. Your great genius has opened new fields in differential equations and dynamics. With your powerful methods in these fields, you have shed new light on the problem of three bodies, on the calculus of variations and on topology.

ARTHUR LOUIS DAY: Under your expert and generous direction the Geophysical Laboratory of the Carnegie Institution has more than fulfilled the purpose of its founder to encourage discovery and the application of knowledges to the improvement of mankind. With skilful new techniques you and your staff have plotted the equilibria of rock formations at atmospheric pressures, have synthetically reproduced the laboratory of nature far below the earth's crust, and have revealed the history of oceans by exploring the strata of their deepest beds.

GILBERT NEWTON LEWIS: An intuitive yet logical investigator, you have with brilliant results brought your own dynamic energy and insight to bear upon the phenomena of forces determining molecular structures. In the School of Chemistry of the University of California you have organized a center of teaching and research which has influenced the work of physical chemists everywhere. It is through minds such as yours that the world comes increasingly to "the knowledge of causes and secret motions of things, and the enlarging of the bounds of human empire, to the effecting of all things possible."

THOMAS HUNT MORGAN: The great figures in science have ever been more than recorders of newly discovered fact. The true pathfinders have been those who, like you, idealize their task and bring to it the fervor of imagination and faith. Preserving always that most difficult balance between old and new you have opened new vistas in the structure of germ cells and the mechanism of heredity which have won a Nobel Prize and acknowledged leadership. Your boldly constructive mind and your enthusiasm have inspired a notable group of co-workers who will carry to dark places the torch you have lighted.

LOUIS MARTIN: As Marie Curie has written, in science we must be interested in things, not in persons. Yet it is with peculiar pleasure that the Franklin Institute and the University of Pennsylvania welcome you to-day as the worthy inheritor of a great tradition. In your studies of the toxins of diphtheria and tetanus, your work on the hospitalization of contagious diseases, and the treatment of sleeping sickness and meningitis you have successfully applied methods learned from your distinguished predecessor. As hospital director and Director of the Pasteur Institute you have brought a new brilliance to the medical science of your country.

SCIENTIFIC NOTES AND NEWS

DR. JOHN J. ABEL, who retired with the title emeritus in 1932 from the professorship of pharmacology at the Johns Hopkins University, now director of the Laboratory of Endocrine Research, has been elected a foreign member of the Royal Society, London. Dr. Abel celebrated his eighty-first birthday on May 19.

DR. ROSS G. HARRISON, Sterling professor of biology at Yale University, has been elected a foreign member of the Royal Swedish Academy of Science, Stockholm.

DR. HARVEY CUSHING, professor of neurology emeritus in the School of Medicine of Yale University and professor of surgery emeritus of Harvard University, has been elected an honorary member of the Biological Society of Vienna.

DR. RICHARD GOLDSCHMIDT, professor of zoology, University of California, has been elected a foreign member of the Royal Society of Copenhagen.

AT the eighty-fifth commencement exercises of the University of Maine the doctorate of science will be conferred on Dr. Harry Steenbock, professor of agricultural chemistry at the University of Wisconsin.

FORMAL presentation of the Mendel Medal of Villanova College to Dr. Thomas Parran, surgeon general of the U. S. Public Health Service, was made at a dinner given in his honor on May 18.

DR. O. A. JOHANNSEN, head of the department of entomology at Cornell University, was given a testimonial dinner on the evening of April 30 by his col-

leagues, former students and graduate students in the department. Nearly two hundred were present at the dinner. Dr. Cornelius Betten acted as master of ceremonies. Brief addresses were made by: Dr. Hugh Glasgow, of the State Experiment Station at Geneva, N. Y.; by Dr. C. E. Ladd, dean of the College of Agriculture; Dr. Arthur Gibson, chief Dominion entomologist of Canada, and by Dr. James G. Needham, of Cornell. Dr. Johannsen, who retires from active teaching at the end of this academic year, responded. He and Mrs. Johannsen are sailing for Europe in June. They expect to be abroad during the coming year. Dr. Johannsen will attend the seventh International Congress of Entomology at Berlin from August 15 to 20.

DR. WILLIAM M. MANN, director of the National Zoological Park, and Mrs. Mann have been awarded the Franklin L. Burr Prize of $1,000 in recognition of the success of their biological expedition to the Netherlands Indies last year. The Burr award originated with the late Mary C. Burr, of Hartford, Conn., who bequeathed in memory of her father a fund to the National Geographic Society, the income to be used in awarding prizes to those members of the society's expeditions considered by the Board of Trustees to have done "especially meritorious work in the field of geographic science."

THE Institute of Medicine of Chicago announces that the Joseph A. Capps Prize of $500 for medical research, founded by the late Dr. Edwin R. LeCount, has been awarded for 1937 to Dr. Ronald R. Greene for his work on "The Experimental Production of Intersexuality in the Female Rat." The award is made annually for the most meritorious investigation in medicine by a graduate of a recognized medical school in Chicago within two years after the completion of an internship or of one year in laboratory work.

CLAY MYERS GREER, research associate in pharmacology at Vanderbilt University School of Medicine, has been awarded the prize given by the Committee on International Congresses of the Federation of American Societies for Experimental Biology for the best piece of work presented by any one in pharmacology with a rank below that of associate professor. This prize consists of a trip to Zurich to the Physiological Congress, which will meet in August. The prize was given to Mr. Greer for his work on "Nor-Epinephrine [β-(3, 4-Dihydroxyphenyl), -β-Hydroxyethylamine] as a Possible Mediator in the Sympathetic Division of the Autonomic Nervous System."

DR. CLARK WISSLER, curator of ethnology at the American Museum of Natural History and professor of anthropology in the Institute of Human Relations at Yale University, was elected president of the American Association of Museums on May 18 at the annual meeting held in Philadelphia.

THE American Association of Pathologists and Bacteriologists at the recent meeting held at Atlantic City elected the following officers for the ensuing year: *President,* Dr. Earl B. McKinley, Washington, D. C.; *Vice-president,* Dr. Carl V. Weller, Ann Arbor, Mich.; *Treasurer,* Dr. F. B. Mallory, Boston, Mass.; *Secretary,* Dr. Howard T. Karsner, Cleveland; *Incoming Member of the Council,* Dr. Paul R. Cannon, Chicago; *Assistant Treasurer,* Dr. Frederic Parker, Jr., Boston; *Assistant Secretary,* Dr. Harold M. Dixon, Cleveland. It was voted to meet next year on April 6 and 7 at the Medical College of Virginia, Richmond.

AMONG members of the faculty of Cornell University who will retire at the end of the year are: Dr. Madison Bentley, psychology; Drs. George W. Cavanaugh and Emile M. Chamot, chemistry, and Dr. Virgil Snyder, mathematics. Among those appointed to professorships are: Dr. Arthur B. Burrell, plant pathology; Dr. Guy F. MacLeod, economic entomology; Dr. Lowell F. Randolph and Frederick Z. Hartzell, chief in research at the Geneva Experiment Station, botany, and Dr. Ralph P. Agnew and Dr. Jacob R. Collins, physics.

AT Yale University Dr. Howard W. Haggard, associate professor of applied physiology, has been promoted to a professorship and has been appointed director of the laboratory of applied physiology to succeed Professor Yandell Henderson, who retires from the directorship at the close of the academic year. Dr. Albert E. Parr, associate professor of zoology, director of the Peabody Museum of Natural History and curator of the Bingham Oceanographic Collection, has also been promoted to a professorship.

DR. KURT GOLDSTEIN, head of the Neuro-physiological Laboratories at the Montefiore Hospital and clinical professor of neurology at Columbia University, has been appointed William James lecturer in philosophy and psychology at Harvard University for the first semester of the academic year 1938–39; Dr. Kurt Lewin, professor of child psychology at the University of Iowa, has been appointed lecturer on dynamic psychology at the Harvard Psychological Clinic for the second semester. Dr. S. Smith Stevens has been promoted to be assistant professor of psychology in the Harvard Psychological Laboratory.

DR. GEORGE KREEZER, research associate in the department of research of the Training School at Vineland, N. J., has been appointed assistant professor of psychology at Cornell University.

PROFESSOR J. NELSON SPAETH, of the Cornell Uni- rsity Agricultural Experiment Station, has been ap- inted professor and head of the department of restry to be established at the University of Illinois. e will also serve as chief of forestry in the Agricul- ral Experiment Station.

DR. W. F. K. WYNNE-JONES, of the University of eading, England, has been appointed to the chair of emistry in University College, Dundee, which will come vacant in September by the retirement of Pro- ssor Alexander McKenzie.

DR. S. S. GOLDWATER, since 1934 commissioner of e department of hospitals, New York City, has an- unced his decision to retire from the service of the ity. The resignation will become effective as soon as is successor is appointed.

DR. HUGH GLASGOW, chief in research in ento- ology at the State Experiment Station, Geneva, N. Y., has been appointed chief of the Division of Entomology, effective on July 1. The appointment ills the vacancy occasioned by the promotion last January of Professor P. J. Parrott to the position f director.

DR. JUSTIN ANDREWS, associate professor of proto- oology at the School of Hygiene and Public Health f the Johns Hopkins University, has resigned to be- ome director of the Division of Malaria Investiga- on of the Georgia State Department of Public Health t Atlanta.

DR. WALLACE M. YATER, professor and head of the epartment of medicine of Georgetown University chool of Medicine, is the recipient of a grant from e American Medical Association to aid in the con- nuation of his studies of the pathogenesis of bundle- ranch block. The first report of this study will ppear in monograph form in the *Archives of Internal Medicine* within the next few months.

THE Commonwealth Fund has made a three-year rant to Western Reserve University for the study of e mechanism of heart failure, to be expended through r. Joseph T. Wearn, professor of medicine.

THE National Advisory Cancer Council has ap- roved the application of Duke University, on behalf f Dr. J. W. Beard, for studies on the properties of rus protein and related material in the amount of ,625, with the understanding that the National Cancer Institute will consider favorably the appoint- ent and assignment of a research fellow to work nder the direction of Dr. Beard.

DR. WALTER B. CANNON, George Higginson pro- essor of physiology, Harvard University Medical School, delivered the William H. Welch lectures at Mount Sinai Hospital, New York City, on May 18, 19 and 30, on "Some New Aspects of Homeostasis" and "The Aging of Homeostatic Mechanisms."

DR. G. H. WHIPPLE, dean of the School of Medicine and Dentistry of Rochester University, spoke on April 19 at the meeting of the Duke Chapter of Sigma Pi, his subject being, "Hemoglobin, Plasma Protein and Tissue Proteins—their Production and Interrelation in the Body."

DR. GEORGE ELWOOD NICHOLS, professor of botany at Yale University and director of the Yale Botanical Gardens, addressed the University of Cincinnati Chapter of Sigma Xi at its annual initiation meeting on May 14 on "Arctic-Alpine Vegetation of North America."

DR. HOMER C. THOMPSON, head of the department of vegetable crops at Cornell University, delivered the Sigma Xi initiation lecture before the Pennsylvania State College Chapter on May 6, on "Temperature Relations of Flowering in Certain Plants."

DR. ERNEST CARROLL FAUST, professor of parasitology and chief of the laboratory of the department of tropical medicine at Tulane University, gave the annual guest lecture of the Mobile Academy of Science on May 4. His subject was "Malaria, with Special Reference to its Epidemiology, Geographical Distribution and Prevalence in the Southern United States."

THE Botanical Society of America and the American Society of Plant Taxonomists have arranged two joint summer meetings for 1938. The first of these meetings will be held at Ottawa, from June 27 to July 1 in connection with the summer meeting of the American Association for the Advancement of Science. The tentative program includes field trips to the peat bog at Mer Bleue, to King's Mountain and adjacent woods and to the sandy district at Constance Bay. A garden party will be held at the Dominion Experimental Farms on the afternoon of June 28. Local arrangements are in charge of a committee of which J. Adams, Acting Dominion Botanist of the Division of Botany of the Dominion Experimental Farms, is chairman. Those members of the two societies who plan to attend the Ottawa meeting should address Mr. Adams and advise him whether they expect to join in the field trips and whether they will bring their own cars. The second summer meeting will be held at the University of Iowa Field Station at Lake Okoboji, Iowa, August 23 to 26. Requests regarding accommodations should be addressed to Dr. W. A. Anderson, Department of Botany, University of Iowa.

THE department of physics of the University of Chicago and the Yerkes Observatory is organizing a symposium on "Recent Progress in the Interpretation of Molecular Spectra and in the Study of

Molecular Spectra in Celestial Objects." It will open on Wednesday, June 22, and is expected to last for four days. The following speakers have tentatively agreed to participate in the program: Professor Gerhard Herzberg, University of Saskatchewan; Professor Davis M. Dennison, University of Michigan; Dr. Hans G. Beutler, University of Chicago; Professor John T. Tate, University of Minnesota; Professor Robert S. Mulliken, University of Chicago; Dr. Rupert Wildt, Princeton University Observatory; Dr. Arthur Adel, Lowell Observatory; Professor N. T. Bobrovnikoff, Perkins Observatory, Delaware, Ohio; Dr. G. H. Shortley, the Ohio State University; Dr. Karl Wurm, Yerkes Observatory, University of Chicago, formerly of the Astrophysical Observatory, Potsdam; Dr. W. W. Morgan, Yerkes Observatory. Astronomers and physicists are invited to attend the symposium and to participate in the scientific discussions. Graduate students attending the summer school of the University of Chicago in the department of physics or the Yerkes Observatory are also invited.

THE New England Geographical Conference held its 1938 meeting in the Institute of Geographical Exploration at Harvard University on May 6 and 7, under the presidency of Robert M. Brown, of the Rhode Island College of Education. Those in attendance were guests of Dr. A. Hamilton Rice, director of the institute, at tea, and afterwards inspected an exhibit of maps prepared by Dr. Erwin Raisz. Harold S. Kemp, of the department of geography at Harvard University, gave the principal address on "The Spanish War; Is Geography Involved?" Papers dealing with scientific geography were as follows: L. O. Packard, "Recreation as a Topic in Economic Geography"; William T. Miller, "New Frontiers in New England"; Earl B. Shaw, "Geographic Influences on Aland's Windjammers"; Louise G. Ramsdell, "Old Highways of Europe and Their Importance"; Edward A. Ackerman, "The Balkan Switzerland." Other papers treated aspects of the teaching of geography.

AMHERST COLLEGE will receive $207,327 by the will of Dr. Ellwood R. Kirby, who died in December, 1935.

As residuary legatee of the late Charles Felix Burke, of New York City, Denison University at Granville, Ohio, receives the sum of $133,834.

THE London *Times* reports that G. Seligman is heading a party of scientific men to the Jungfraujoch Research Institute in Switzerland to undertake scientific research work on glaciers. This will be the first British expedition to spend its whole time in studying glaciological problems, and it will form a continuation of Mr. Seligman's previous researches on the nature of snow. The party will spend five months at the institute, at a height of over 11,000 feet, and it will consist of T. P. Hughes, of the Physical-Chemical Laboratory; M. F. Perutz, of the Crystallographic Laboratory; A. E. Benfield, of the department of geodesy and geophysics, and E. A. Ferguson, of the department of geography, all of the University of Cambridge. They will investigate the transition of firm (or partly consolidated snow) into glacier ice; the movement of glaciers; the formation of ice-bands, and the connection, if any, between those in the névé regions and those near the snout of the glacier. In addition, Mr. Hughes will carry out certain experiments on the friction of solid bodies on ice, in connection with his work at the Physical-Chemical Laboratory. Mr. Seligman has been granted a Leverhulme Research Fellowship for the purpose of this research, and the expedition is also supported by the Royal Geographical Society, the Ski Club of Great Britain and the Alpine Ski Club.

DISCUSSION

THE LOWER SONORAN IN SOUTHWESTERN UTAH

READERS of the interesting articles of W. P. Cottam[1] and F. R. Fosberg[2] may be interested in additional information concerning the effect of the prolonged subzero weather reported by Cottam on plants of the Lower Sonoran zone in southwestern Utah.

The writer visited the Long Valley region on the upper Virgin River (altitude 6,000 feet) on May 7 and 8, 1937, and noted as a common occurrence dead brown twig tips from one to six inches in length on many but not a majority of the junipers, *Juniperus utahensis,* in the region east of Zion Canyon in the Upper Sonoran zone. On repeated visits to the Long Valley region in early August, late August, mid-September and late November, the dead twig tips were less and less conspicuous until by fall they were scarcely noticeable.

On a visit to the Virgin River lower down (3,000 feet) between St. George and Hurricane on August 23 and 24, 1937, and again on September 12, it was noted that in that vicinity practically all the plants of both the creosote bush and mesquite showed frost injury, ranging from dead twig tips through dead limbs to dead trunks, but in no cases observed were any

[1] W. P. Cottam, SCIENCE, 86: 563–564, June 11, 1937.
[2] F. R. Fosberg, SCIENCE, 87: 39–40, Jan. 14, 1938.

plants completely dead. The great majority had green shoots growing from the main stems or their branch limbs. Only a few cases were observed where the green shoots were growing from twigs or from the crown only. In one case, that of a mesquite nearly ten inches in diameter, all the branch limbs were dead, and the thrifty green shoots from the main trunk were fast filling the vacant spaces between the dead limbs.

On a later visit, November 24 to 26, into the Virgin River Valley, particular attention was paid to the creosote bushes in several places, near Hurricane, Washington, Santa Clara and the Beaver Dam slope, all in Utah (altitudes 2,500 to 3,000 feet). These observations confirmed the previous conclusion that the large majority of the plants had suffered frost damage, but in no observed case was the plant entirely dead. The thrifty green shoots of the summer had, however, so grown that the dead portions were nearly inconspicuous, and the plants had so far recovered as to present an almost normal appearance.

It would seem then from these limited observations that at the places investigated along the lower portions of the Virgin River Valley the frost damage to the creosote bush was considerably less than was originally anticipated by Cottam. The plants exhibited a variable ability to resist the prolonged cold, some escaping almost uninjured, some receiving moderate injury and a few being killed down to the crown. All the plants examined showed a remarkable "comeback" from the damage.

The limits to the Lower Sonoran are abruptly reached in the foothills surrounding the Virgin River Valley, these limits being set by increasing altitude about 500 to 1,000 feet above the valley floor. Presumably the valley floor is so far down in the Lower Sonoran that the unusual cold would not be sufficient to permanently transform its vegetation, and Utah would be in no danger of losing its Lower Sonoran zone. It would be interesting to know, however, whether the cold spell was instrumental in shifting the upper limit of the Lower Sonoran downward. Would the extra cold concomitant with the 500 to 1,000 feet rise in altitude be sufficient actually to kill the more susceptible plants. This point does not seem to be settled by the observations. If some of the plants were killed, were there enough to move the limit or were there enough of the more resistant plants left to maintain the limit? If there is any shift at all in the limit of growth of the creosote bush the fluctuation would probably fall within very narrow limits, as would be expected where the limits are set by altitude instead of latitude.

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FOREST WILDLIFE AND SILVICULTURE[1]

IN this informal talk this evening on "Forest Wildlife and Silviculture," it is my intention by way of introduction to touch briefly on the broad topic of forests and forest wildlife and then turn the attention of the group to one specific phase of this broad subject which bears closely on silvicultural problems.

We have all heard a great deal, particularly in recent years, of the role that forests play in wildlife production, particularly in the production of game birds and animals, grouse, turkey, deer, elk and the forest's importance in the production of fur-bearing animals, beaver, mink, marten and others almost too numerous to mention. Undoubtedly this phase of the forest wildlife picture is an important one and justifies the attention it has been given. It is a field which presents many interesting and difficult silvicultural problems bearing on wildlife which I wish by no means to minimize. Certainly the present wide division of opinion on whether or not timber production and wildlife and recreation can be combined on the same area or whether some areas must be devoted strictly to game production, some to recreation and still others to timber production, is a land-use problem of great moment and one on which we need a great deal of additional information on what various silvicultural practices will mean in terms of wildlife. The problems on this side of the picture might be summed up in the question: "How do forests affect wildlife?"

It is the reverse of the picture, "How does wildlife affect forests?" to which I would like to turn your attention at this time. This is a much less discussed field. The principal characters in the drama, if you will, are not the noble elk or the empire-building beaver, but such lowly creatures as the white-footed mouse, the chipmunk and the squirrel. But the story is an interesting one to the biologist, nevertheless, and one of importance from a silviculturist's standpoint.

Now if my biological audience will permit me—what is silviculture? One of the lesser known and least practiced of the arts, mainly the art of tending forests, including methods of establishment, their care during growth, their harvesting at maturity. In other words, the silviculturist occupies the same rich field in forestry that the agronomist occupies in agriculture—he is interested primarily in the art of crop production. The problems are, of course, very different in many important respects. The silviculturist must deal with a natural vegetation unit of exceedingly great biological complexity, consisting often not only of a diverse mixture of tree species but numerous shrubs, herbs, fungi, insects, animals and a complex

[1] Presented before the Biological Society of Washington at the 853d meeting, October 16, 1937.

soil flora and fauna. These organisms interact on one another and on their environment and are acted on in turn. In a normal mature forest the various biotic factors are usually in reasonably good balance. But if this balance is greatly disturbed, and this the silviculturist must do in the process of harvesting the timber crop, then we must know what we are about if disaster is to be avoided.

Accordingly, it is the period immediately following the timber harvest—the critical regeneration period—with which the silviculturist is most keenly concerned. What changes can and must be made in the micro-environment and how will these in turn affect regeneration of desirable tree species, the food supply of forest animals, the environment of the flora and fauna of the forest floor? Certainly clear cutting, at one extreme, will make marked changes in the micro-climate of the cut-over area, while light tree selection, consisting of the removal of only a few scattered trees per acre, may have little or no effect. In addition the silviculturist must frequently deal with lands previously devastated by fire or logging, more often a combination of these factors, which have created an environment for tree seedlings and other elements of the forest complex, including the forest animals, entirely different from those prevailing in the untouched stand.

In this critical regeneration period the seed or plant-eating rodent often plays a dominant role. Let me illustrate my point by a few examples of the type of thing I have in mind and some reference to its extent as we know it to-day:

Very frequently the silviculturist must depend on seed furnished by seed trees or adjacent uncut timber, to produce the new crop. In many types, for example, in the great ponderosa pine-Douglas fir belt running the length of the Rocky Mountain region, a great deal of seed is gathered by squirrels before the crop is opened and cached for a food supply. It is true that man in turn often robs these caches and uses the seed for growing planting stock or for occasional seed-spotting operations. But in normal or lean years the squirrels and chipmunks clean up the seed crop of the larger seeded species so thoroughly that natural regeneration is a failure. This is true in spite of the enormous crops of seed produced even in only fair to good seed years. Seed yields in western coniferous forests are frequently better than 40,000 seed per acre of the larger seeded species such as Douglas fir or ponderosa pine and several hundred thousand to even several million seeds per acre of small seeds, such as western hemlock or western red cedar. Seed which escapes the squirrels and reaches the ground is often gathered and stored or eaten by chipmunks and mice, though occasionally some of this is forgotten and the seed germinates to form a natural seed spot. Accordingly, throughout this immense region, the silviculturist must first devise a method to meet this rodent problem before other environmental factors can be considered. In general, satisfactory regeneration throughout this region requires a bumper crop so large that the rodents can glut themselves on it and still leave an ample supply for regeneration. This must be followed by a reasonably favorable season, so that a sufficient number of seedlings will survive the rigors of the critical first season.

This situation is by no means confined to the ponderosa pine type. Rodents and birds,[2] particularly juncos, through their influence on seed supply, also play an important and at times a key role in the adjacent coniferous forests of California and the Pacific Northwest. Not only do they destroy seed; they also feed extensively at times on newly germinated, succulent seedlings, thus encroaching further upon the supply available to restock the forest. In the Southern pineries birds play a particularly important role, the mourning dove, southern meadow lark, blackbirds and occasionally sparrows being the chief offenders. In natural regeneration rodents and birds if unmolested often play an important part in determining the composition as well as the abundance of the seedling crop through their preference for larger seeds and seedlings. They may destroy the entire crop of such large-seeded conifers as western white pine, ponderosa pine and Douglas fir, while smaller seeded species, cedar, lowland white fir, go unscathed and are more abundant as a result in the regeneration stand. In the South rabbits will eat and destroy slash pine and pass over longleaf pine in the early seedling stages. Although the role of these small forest inhabitants in their relationship to natural regeneration is best known in the West and South, they play a less known but undoubtedly influential role in other regions.

In addition, they play a dominant role in artificial seeding operations and are a major factor to be considered in the successful establishment of plantations from nursery grown stock. Direct seeding by man either broadcast or in seed spots, has been a patent failure almost anywhere in the United States where rodents and birds are not controlled or excluded. Planting operations—in both the nursery and field planting phases, suffer heavily from rodent depredations. Often rodents must be fenced out or controlled in other ways, before planting can be carried out successfully. When the snowshoe rabbit is abundant

[2] The role of rodents and other important forest and range inhabitants, is being studied intensively by members of the U. S. Biological Survey under the supervision of Dr. W. B. Bell. These investigations have proved extremely helpful, and most of the specific references herein to the role of important forest inhabitants are based on this work.

throughout the Lake States, for example, few plantations can survive satisfactorily without fencing or other protection. Horn tells us that direct seeding in the California pine region is hopeless unless the mouse population is held to less than one mouse per 50-trap nights.

These few citations serve to emphasize not only the importance but the widespread extent of the biological factor in silvicultural operations. No doubt other phases of it will come to our attention as time and resources permit the expansion of biological investigations to additional regions and problems.

The study of the animals themselves, their life habits and so on, are of course primarily the task of the forest biologist. Some of the questions which the silviculturist must put to the biologist are:

(1) What are the important forest-inhabiting animals and birds affecting forests and forest practices?

(2) What is their life cycle, their food habits, etc.?

(3) What effect will the destruction of other animals, including predators, have on them?

(4) How are they affected by environmental changes which the silviculturist may make—as through clear cutting, etc.?

The forester must have the answer to these and similar pertinent questions before satisfactory forest-cutting practices can be worked out in silvicultural terms.

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THE FORMALDEHYDE-PROTEIN REACTION

CLARK and Shenk[1] in a study of the action of formaldehyde upon proteins found evidence which they interpreted upon the basis of compound formation. This evidence, observed by x-ray diffraction methods, consisted essentially of two new interplanar spacings corresponding to values of 2.6 and 3.9 A.U.

The presence of these new diffraction rings in the case of fibrous proteins characterized by ready swelling in alkali (feather, hair, tendon) and their absence in proteins relatively inert to alkali (silk) was construed to be indicative of reaction at the amide nitrogen. The mutually perpendicular fibering of these new interferences in the case of fibrous proteins was considered as being in accord with this interpretation.

Subsequent work at this laboratory undertaken at the suggestion of Professor J. H. Highberger and in conjunction and agreement with experimental work on proteins at the United States Regional Soy Bean Industrial Products Laboratory at this university indicated, however, that the new interferences could be accounted for upon the basis of the polymerization of formaldehyde retained in the protein.

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BACTERIA IN DUST-LADEN SNOW

ON March 5, 1938, a snowfall occurred in the Ottawa district which brought down with it a considerable amount of solid matter sufficient to produce a distinct brownish discoloration. According to the Meteorological Division, Department of Transport, such winter dust falls are reported from time to time from certain stations in Northern Ontario and Quebec. The dust is believed to have originated in the Western States, a low pressure area centered over Arizona and Texas on March 3 to 4 having reached Michigan and Ontario on March 5. Carried at high levels the dust current encountered cold air moving west when condensation to snow brought the dust particles down.

Bacteriological analysis of samples, collected in open country previously covered by fresh clean snow, gave a count of 4,370,000 organisms per gram of deposit. Examination of plate colonies showed them to consist almost entirely of spore-forming types, only one non-spore-former, a micrococcus, occurring on the highest dilution plate of twenty-five colonies. *Bacillus megatherium* was the most abundant species. Others noted were *B. vulgatus, B. mesentericus, B. mycoides, B. simplex, B. cereus* and *Bacillus sp.* The predominant organisms encountered were thus types commonly found in soil and which might be expected to withstand well such adverse conditions as desiccation and low temperature.

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SOCIETIES AND MEETINGS

THE NOTRE DAME SYMPOSIUM ON THE PHYSICS OF THE UNIVERSE AND THE NATURE OF PRIMORDIAL PARTICLES

A SYMPOSIUM dealing with the structure of the universe, cosmic rays and the ultimate constituents of matter and attended by more than 100 visiting scientists from 30 other colleges and universities was held at the University of Notre Dame on May 2 and 3, 1938. The symposium, arranged by Dr. Arthur Haas, comprised three public lectures and several technical sessions at which Dr. Arthur H. Compton, of the University of Chicago, Dr. Harlow Shapley, of Harvard University, Dr. Carl D. Anderson, of the Califor-

[1] *Radiology*, 28: 357, 1937.

nia Institute of Technology and Dr. Gregory Breit, of the University of Wisconsin, presided.

Professor Shapley's lecture dealt with the distribution of matter in the metagalaxy. Of the six possible categories of material in metagalactic space, we have, according to Dr. Shapley, positive knowledge of the existence of only two, namely, galaxies and radiation. We have preliminary evidence of a third category—star clusters. Of isolated stars and of meteorites and gas, we have no evidence and can make only rather insecure inferences. Calculations based on the "short time-scale" show that the density of intergalactic radiation is approximately 10^{-35} grams per cubic centimeter. A few of the remotest globular clusters, studied at Mount Wilson and Harvard observatories, appear to lie beyond the bounds of our galactic system, but they are still within the local group of galaxies. The principal known constituents of the metagalaxy are the spiral, spheroidal and irregular galaxies. The rough uniformity of their distribution throughout space has permitted preliminary simple deductions concerning metagalactic structure. New investigations of groups, clusters and clouds of galaxies, and especially of important population-gradients within a hundred million light years of the observer, impel us, however, to revise the concepts based on the hypothesis of uniformity. In particular, a well-surveyed region 110 degrees long in the southern galactic hemisphere shows a remarkable density-gradient—near the south pole the density is more than five times that near the equator. A study of the 90,000 faint galaxies in the south galactic polar cap reveals large inequalities in population density. On the basis of this extensive new material it is found that tests of the expanding universe hypothesis are still indeterminate. The study of the nearest and most significant of the supergalaxies, the cluster in Virgo, has shown the reality of the long extension of the system into the southern hemisphere. The cluster is more than five million light years in extent and is composed almost exclusively of galaxies brighter than the 15th magnitude. A survey of galaxies around the north pole of the skies serves to outline the clouds of absorbing material that lie in our own galaxy in that direction. These various results are all a part of a survey from Harvard's northern and southern stations of the distances and brightnesses of the observable galaxies, estimated at about 600,000, that lie within a hundred million light years of the milky way.

Canon Georges Lemaître, of the University of Louvain, at the present time visiting professor at the University of Notre Dame, discussed the significance of the clusters of nebulae. He compared new data about these clusters with the theory propounded by him, according to which the clusters are equilibrium regions of the expanding universe where the cosmical repulsion and the gravitational attraction balance one another. This hypothesis enables one to compute a theoretical mass of a nebula from the observed red-shift. The mass found in this way is 700 million suns in excellent agreement with the value found by Hubble from spectroscopic rotation. On the contrary, Sinclair Smith, who rejects Lemaître's hypothesis and interprets the large peculiar velocities of nebulae in clusters as an indication of a predominant effect of gravitation, finds a mass which is a hundred times bigger than Hubble's value. The big velocities of the nebulae of a cluster are easily explained by the theory of the expanding universe. The typical clusters of nebulae are extreme cases of the large fluctuations of density which have been found by Shapley and Hubble. When we take account of the uncertainties due to the large dispersion of the velocities in the clusters, it is clear that the discrepancy from a perfect linearity of the velocity-distance relation is within the observational errors and that the cosmological consequences deduced from them by Hubble (which practically imply the rejection of the relativistic theory of the expanding universe) are not really justified by actual observations.

In his paper on the heat of the stars and the building of atoms in the universe Dr. William D. Harkins, of the University of Chicago, arrived at the conclusion that the composition of the stars is about what it should be if they began their existence billions of years ago as bodies composed of hydrogen alone, provided there has been some process which has been able to produce the great amount of neutronic matter essential for the building of heavier atoms.

The topic of Dr. Arthur H. Compton's lecture was the question "Whence Cosmic Rays?" With the discovery of the effect of the earth's magnetic field, it became evident, as Dr. Compton showed, that the cosmic rays were not like gamma rays but consist mainly of electrical particles. These in general do not go in straight lines. Thus it becomes impossible from the observed isotropic character of the rays as they reach the earth to infer that their origin is likewise isotropic. In fact, following a suggestion very recently made by Alfven, it may be shown that if the cosmic-ray particles are predominately of one sign, there must be slowly moving ions following the motion of the stars which, together with the cosmic ray particles, would produce large magnetic fields if the cosmic ray particles themselves do not follow the stars. These fields might in fact be comparable with the magnetic field of the earth and should in any case cause curvature of the paths of the cosmic ray particles that would be short compared with interstellar distances. Alfven thus concludes that the observed isotropic character of the cosmic rays tells nothing about their point of origin but is a consequence merely of the fact that

the rays consist of electrically charged particles. This result means, according to Dr. Compton, that the cosmic rays can not readily escape from the galaxy nor could rays from outside the galaxy readily come into it. Any sidereal time variation such as that ascribed to a motion of the earth relative to cosmic rays coming from outside the galaxy should thus be impossible unless there are some rays of a non-galactical type. On the other hand, no great source of cosmic ray power would be required since the energy, once developed, would stay within the galaxy. Thus, although the cosmic ray power reaching the earth is roughly equal to that of starlight, the rate of production of cosmic ray energy by the galactic system would be far less than that of starlight. It would seem possible, in fact, that in the interaction of cosmic ray particles on stars in motion relative to each other there might be found a source of the new energies of the cosmic rays. This source would consist of the gradually increasing energy of the particles as they bounce back and forth among the moving stars.

Interesting aspects of the cosmic ray problem were discussed by Dr. Anderson. He dealt especially with the difficulties which inhere in the attempts to explain the observed cosmic-ray phenomena in terms of the assumption that the cosmic-ray particles are practically all protons and positive and negative electrons. According to Dr. Anderson, these difficulties may be resolved by postulating the existence of new particles of unit positive and negative charge and with a mass whose magnitude lies between that of a proton and that of an electron. Data pertaining to this question come from two types of observations, firstly determinations of the penetrating power and of the production of secondaries by cosmic-ray particles of various energies, and secondly, by observation of heavily ionizing particles under conditions where information concerning their curvature in a magnetic field and their range may be obtained.

Dr. Manuel S. Vallarta, of the Massachusetts Institute of Technology, discussed the influence of the magnetic field of the earth on cosmic-ray particles and summarized the results of his investigations in the following way: At a given point of the earth particles of a given energy may arrive only from certain regions of the sky; there is a cone of complicated shape within which all directions are allowed, another cone outside which all are forbidden; in the intermediate regions certain directions are allowed and the rest forbidden. The boundaries of these several regions are determined from a study of the trajectories of the primary rays. Since the equations of motion can not be integrated in terms of known functions, the trajectories were found by means of Bush's differential analyzer, which has played a very important role in these investigations. Conclusions can be drawn that most of the primary cosmic rays are electrically charged particles and that they are predominantly—at least three quarters—positively charged.

Dr. J. F. Carlson, of Purdue University, gave a detailed theory of cosmic ray particles. According to Dr. Carlson, the shape of the ionization curves in the upper atmosphere and of the Rossi transition curves in various absorbers can be explained by assuming that the incoming rays consist in part of highly energetic electrons and positrons, whose behavior can be predicted from the quantum theory of radiation. According to theory, charged particles will radiate and gamma-rays will produce electron-positron pairs in nuclear fields. This multiplicative process will continue until the original energy of the gamma-ray is distributed over a large number of less energetic particles; these will lose energy largely by collision and ionization. Specific predictions of the theory are in satisfactory agreement with experiment, and direct evidence for the nature of the process has been given. Effects observed for large thicknesses of absorbing material may be explained by the existence of a penetrating component which is not electronic in character.

The nature of forces between primordial particles was discussed by Dr. Breit. The force between two protons is known to a certain extent through the experiments on the scattering of protons in hydrogen. The interpretation of these experiments by Breit, Condon and Present, and with improved accuracy by Breit and Stehn, shows that this force is nearly the same as the force between a proton and neutron as determined by Fermi and Amaldi by scattering neutrons in hydrogen. Comparison of mass defects of isobaric nuclei indicates also approximate equality of these forces to the neutron-neutron-force. Although the forces are approximately equal, there appears to be a definite indication that the proton-proton force is smaller than the neutron-neutron force and almost as definite evidence that it is smaller than the proton-neutron force. Theoretical considerations indicate that the forces are of an exchange character.

Dr. Eugene Guth, of the University of Notre Dame, presented a paper in which he treated the possible wave-equations for the primordial particles. He discussed especially the possible disintegration of nuclei by fast electrons. Experiments for detecting such an effect with beryllium are running with the electrostatic generator of the University of Notre Dame, which was recently constructed by Dr. Collins and gives a current of 30 microamps at two million electron volts (corresponding to the electron emission produced by 6 kg radium).

In his paper on "Cosmic Constants" Dr. Arthur Haas, of the University of Notre Dame, derived a new relation connecting constants of atomic physics on the basis of the theory of the universe. This relation states

that the radius of the electron is related to the Compton wave-length of the proton as 3 to $\sqrt{2}$. This may be interpreted as indicating that in the state of equilibrium of the universe one third of its primordial particles are protons, one third electrons and one third neutrons.

THE DEPARTMENT OF PHYSICS
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SPECIAL ARTICLES

IMMUNIZATION AGAINST EQUINE ENCEPHALOMYELITIS WITH CHICK EMBRYO VACCINES[1]

EQUINE encephalomyelitis is a virus disease which, during the past few years, has become increasingly prevalent in many parts of the United States. Fortunately, vaccines capable of producing immunity in susceptible animals can be prepared by formalinizing brain tissue from animals dying of the disease.[2,3] The horse brain now used for large-scale vaccination constitutes a relatively poor and inconstant source of virus. There is much evidence that the immunizing capacity of a vaccine of this sort is proportional to the amount of virus in the tissues before treatment with formalin. We have accordingly sought to produce a better vaccine by utilizing the exceptionally infectious tissues of chick embryos[4] diseased with the virus.

The high virus content of embryos has been emphasized by the fact that it has proved possible to isolate[5] from them, but from no other tissues, a homogeneous substance which seems to be the infectious agent. We have already prepared formalinized extracts of such tissues and have demonstrated that the immunizing principle they contain can be concentrated by ultracentrifugation.[6] In further experiments we have now studied the immunizing capacity of the formalinized embryonic tissues themselves and have compared it with that of the usual vaccines made from horse brain.

The viruses of both the Eastern and Western strains of equine encephalomyelitis grow equally well in chick embryos. The tissues of embryos diseased with the Eastern strain virus regularly attain a titre of 3×10^9 and under proper conditions 3×10^{10} mouse infective units per gram. The titre of the Western strain chick virus routinely lies between 3×10^8 and 3×10^9 m.i.u. per gram. The virus concentration in these tissues is 1,000 to 10,000 times greater than in the most infectious horse brain we have examined and the chick vaccine has proved to be correspondingly more effective as an immunizing agent.

Chick vaccine against the Eastern strain of equine encephalomyelitis has been tested by injecting guinea pigs with two doses at an interval of seven days. Two weeks after the second injection they have received an intracerebral[7] inoculation of 500 minimal lethal doses of virus-diseased horse brain. Of thirty animals vaccinated with eight different batches of vaccine every one was solidly immune and survived the test inoculation of virus with no evidence of disease. All control animals succumbed promptly.

Western strain chick vaccine is equally effective in protecting guinea pigs. One group of experiments utilizing 60 animals has demonstrated its superior immunizing capacity compared with that of a corresponding horse brain vaccine. The chick vaccine protected every tested guinea pig against 1,000 m.l.d. of virus, whereas no animal receiving the horse brain vaccine survived a test injection of 100 m.l.d. In preliminary experiments it has also protected every vaccinated horse against the intracerebral injection of enough virus to kill all the control animals.

In these experiments the vaccine consisted of a 10 per cent. diseased tissue suspension containing 0.4 per cent. formalin. A 1 per cent. chick vaccine has protected about 60 per cent. of the vaccinated animals; more dilute vaccines have proved worthless.

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1 The part of this work carried out at Duke University has been made possible through the interest and aid of Lederle Laboratories, Pearl River, N. Y.

2 M. S. Shahan and L. T. Giltner, *Jour. Am. Vet. Med. Asn.*, 84: 928, 1934.

3 P. K. Olitsky and H. R. Cox, *Jour. Exp. Med.*, 63: 745, 1936.

4 E. Higbee and B. Howitt, *Jour. Bact.*, 29: 399, 1935.

5 R. W. G. Wyckoff, *Proc. Soc. Exp. Biol. and Med.*, 36: 771, 1937.

6 J. W. Beard, H. Finkelstein, W. C. Sealy and R. W. G. Wyckoff, SCIENCE, 87: 89, 1938.

7 Operations on animals were made under full ether anesthesia.

PROTOPLASMIC STREAMING, ELECTRIC POTENTIALS AND GROWTH IN COLEOPTILES OF TRITICUM AND AVENA

THE effect of electric potentials on protoplasmic streaming in coleoptiles of Triticum and Avena in relation to transport and growth has been studied. Cholodny *et al.*[1] have reported that applied currents mainly decrease growth; Lund *et al.*[2] relate polarity of the plant with observed electric polarity, while on the other hand Clark *et al.*[3] report that the electric

1 N. Cholodny and E. Sankewitsch, *Plant Physiol.*, 12: 385, 1937.

2 E. J. Lund, *Jour. Exp. Zool.*, 51: 265, 1928.

3 W. G. Clark, *Plant Physiol.*, 12: 409, 1937; *ibid.*, 12: 737, 1937.

polarity of plants changes independently of polarity of growth. A study of processes primary to the above reactions, namely the protoplasmic streaming, leads towards the explanation of these phenomena.

The optical system used for the observation of protoplasmic streaming had a high resolving power, and only the smallest visible moving particles were used as a measure.

The coleoptiles were not cut lengthwise and placed in water but were kept intact in air, with a small piece of tissue on the lower side removed in order to yield a better visibility. The objective of the microscope was immersed directly upon the tissue with a special immersion oil. This immersion medium of the correct refractive index had no effect upon the living cells and increased the visibility of the smaller particles through its capacity to diminish scattering of light due to intercellular airspaces, etc.

No decrease of the protoplasmic streaming due to lack of oxygen was observed with this technique (over a period of 10 to 18 hours). Electric currents of 0.01–500 μ amp. were applied to the coleoptile over a distance of 2 cm by means of Ag AgCl electrodes.

Constant strong currents yield an effect after only a few seconds, and ultimately disintegrate the protoplasm. Currents of about 4 μ amp. cause cessation after 5 to 10 minutes, while recovery takes place after several hours. Currents of about 0.1–0.01 μ amp., however, cause a decrease of rate of streaming after 15 to 30 min. The threshold for the different cells varies, due to differences in conductivity, which can be measured in this way. Short exposures to currents cause comparable changes in streaming.

Under the conditions of our experiments no marked difference in the effect on streaming velocity was detected when the current flow opposed the "inherent" electric polarity of the coleoptile, or when it supplemented the "inherent" polarity.

Growth measurements with a horizontal microscope made simultaneously on different plants after application of the same currents show identical decreases in growth. Measurements of transport by means of curvatures in parallel experiments show the relation between protoplasmic streaming, transport of auxins and growth. Together with the data of Bottelier[4] on the parallelism between phototropic and protoplasmic spectral sensitivity, and the other data reported previously, this third parallelism between protoplasmic streaming, transport and growth supports the viewpoint that changes in bio-electric potentials have an effect similar to that of applied potentials. These changes in bio-electric potentials, due to modifications in external and internal conditions, change the protoplasmic streaming, and hence the transport of auxins, and finally the growth. The differences between electric and growth polarity can thus be understood.

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[4] H. P. Bottelier, *Rec. d. Trav. bot. neer.*, 32: 287, 1935.

THE RELIABILITY OF PRINCIPAL COMPONENTS

The principal components of a set of intercorrelated statistical observed variables can be obtained by applying the Hotelling technique to the matrix of intercorrelations among the observed variables.[1] The principal components thus obtained are independent variates, which as Girshick[2] has shown, may be as many or fewer than the number of observed variables. Moreover, in the same paper, Girshick demonstrates that the component loadings obtained from the Hotelling technique are maximum likelihood statistics, and further that the principal components are obtained in order of their importance. The first principal component, therefore, is shown, under certain general conditions, to be the independent variate which has the least error variance, and the greatest mean-square correlation with the observed variables. The second principal component is the independent variate which has the next least error variance and the next greatest mean-square correlation with the variables, etc.

If a set of observed variables is resolved into principal components, the observed variables can be expressed in terms of the independent variates. In terms of Hotelling's development

$$\gamma = \frac{a_j z_j}{k}$$

where γ is a person's score in the terms of the independent variate, where $\frac{a_j}{k}$ are the weights to be applied to the z_j which are the observed variables expressed in standard score form.

An estimate of the reliability of the principal component scores may be obtained if it were possible to estimate the correlations of the γ scores from one battery of observed variables with the Γ scores from a comparable battery of observed variables. Such an opportunity was given by the testing of a group of 107 individuals made available to the senior author by the Emergency Relief Bureau of New York City and by a partial grant-in-aid by the Columbia University Council for Research in the Social Sciences. The individuals were given all the Thurstone Scales for the "Measurement of Social Attitudes" in print in July, 1934. The Form A of each scale was given first, then after a lapse of two weeks, the comparable Form B of each of the same scales was given.

[1] Harold Hotelling, *Jour. Educ. Psychol.*, 24: 417–441 and 498–520, 1933.

[2] M. A. Girshick, *Jour. Am. Statist. Asn.*, 31: 519–528, 1936.

For purposes of analysis, five of the scales were selected for resolution into principal components. These scales were:

Attitude toward the Bible	Scale No. 29
Attitude toward God (the reality of God)	Scale No. 21
Attitude toward Sunday observance	Scale No. 26
Attitude toward censorship	Scale No. 28
Attitude toward treatment of criminals	Scale No. 9

The Hotelling principal components for each of the batteries is given in Table 1.

TABLE 1

THE PRINCIPAL COMPONENTS FOR TWO COMPARABLE BATTERIES OF THURSTONE ATTITUDE SCALES

Principal Components for Battery A					
	γ_1	γ_2	γ_3	γ_4	γ_5
Root	2.97	.48	.37	.19	.12
Per cent. of total variance	72	11½	9	4½	3
Correlation of the γ's of Battery A with					
Bible A	.83	−.00	−.27	−.26	.17
God reality A	.87	−.01	−.28	.07	−.25
Sunday observance A	.69	.56	.14	.14	.07
Censorship A	.75	−.14	.45	−.18	−.09
Criminal A	.69	−.39	.04	.27	.14
Principal Components for Battery B					
	Γ_1	Γ_2	Γ_3	Γ_4	Γ_5
Root	3.03	.49	.30	.26	.06
Per cent. of total variance	73	12	7	6	2
Correlation of the Γ's of Battery B with					
Bible B	.86	−.22	.09	−.21	.17
God reality B	.89	−.25	.04	−.14	−.18
Sunday observance B	.76	.25	.35	.26	.00
Censorship B	.68	.53	−.23	−.16	.00
Criminal B	.69	−.20	−.33	.32	.02

Each individual's score was resolved into γ and Γ scores for each of the two batteries. The correlations between the γ and Γ scores were then computed. These are reported in Table 2.

TABLE 2

THE INTERCORRELATION OF PRINCIPAL COMPONENT SCORES DERIVED FROM TWO COMPARABLE TEST BATTERIES OF THURSTONE ATTITUDE SCALES*

	γ_1	γ_2	γ_3	γ_4	γ_5
Γ_1	.95	.01	−.01	.06	−.03
Γ_2	.01	.20	.65	−.20	.10
Γ_3	.02	.61	−.13	.05	−.02
Γ_4	−.04	.06	.16	.58	.15
Γ_5	.07	.01	−.04	−.22	.32

* Where γ refers to the principal components of Battery A and Γ refers to the principal components of Battery B.

In a sense, the correlations of Table 2 are an estimate of the reliability of the principal components, since they are correlations between a test and, presumably, a comparable form, *i.e.*, considering Γ_1 a comparable form of γ_1; Γ_2, a comparable form of γ_2; etc. The reliabilities thus are .95, .20, −.13, .58 and .32. Obviously all components beyond the first are too unreliable for individual prediction. In other words, information of the five scales might have been obtained best by one good test. Further, it should be noted that $r_{\Gamma_2\gamma_3}=.65$ and $r_{\Gamma_3\gamma_2}=.61$, indicating that an inversion in the order of importance of the principal components occurred in Batteries A and B.

If account is taken of the inversion the reliabilities of principal components are in order .95, .65, .61, .58 and .32 indicative of increasing error variance with decreasing importance of the principal components. This is to be expected, since each successive component contains less of true information and more of error variance. As a matter of fact, the Hotelling method squeezes the error to the last and least important component.

The intercorrelations of the γ's of Battery A are zero, except that $r_{\gamma_1\gamma_1}$, $r_{\gamma_2\gamma_2}$, etc., equal 1. Similarly, the intercorrelations of the Γ's of Battery B are zero, except that $r_{\Gamma_1\Gamma_1}$, $r_{\Gamma_2\Gamma_2}$, etc., equal 1. Yet certain of the intercorrelations between γ and Γ, excepting those between γ_1 and Γ_1, γ_2 and Γ_3, γ_3 and Γ_2, γ_4 and Γ_4 and γ_5 and Γ_5 differ significantly from zero.

The causes of the lack of stability in the results may be due, among others, to the lack of comparability in the scales, the relative unreliability of the scales, the smallness of the sample, the variability in the subjects and the like. Nevertheless, it seems reasonable to require an additional condition of statistical factor methods, *viz.*, reliability of components.

The reliability of principal components beyond the first is such as to lead one to believe that psychological nonsense may be a consequence of a too devoted dependence upon factor methods. Traits beyond the first will be inadequately identified and, hence, frequently misnamed.

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